All–optical high bit–rate multiplexer

Technical field:

The present invention relates to an optical module and a method for synchronizing an optical data signal. The invention is based on a priority application EP 01 440 052.7 which is hereby incorporated by reference.

Background of the invention:

As wavelength division multiplexing (WDM) network technology matures, ultra fast optical time division multiplexed (OTDM) packet network are attracting attention because they offer more flexible and efficient communication than WDM networks. It should be noted that all–optical signal processing functions necessary for ultra fast OTDM system ($\geq$ 40 Gbit/s) are also beneficial even in WDM optical communication systems. If simple and reliable all–optical signal processing technologies are available, these may improve the system design of transmission schemes limited by the electronic devices and instruments. Here, the key is the novel kinds of optical devices that make possible some simple but ultra fast signal

processing functions, including the generation of stable ultra short light pulses, beyond the speed limit of the present electronics.

In general, information is coded in the electrical using multiple stage of electronic multiplexer (ETDM). Today, it seems commercially practicable to operate with such a scheme at bit-rates up to 20Gbit/s and 40Gbit/s in lab version. However, the main problem is the actual and non-degraded conversion of the data from the electrical to the optical domain. For that purpose, broadband intensity modulators often based on $LiNbO3$ intensity modulator or integrated electro-absorption modulator which require large peak to peak voltage driver have been considered.

An alternative solution is the use of OTDM (RZ format) using passive optical couplers and delay-lines, which has the main advantage of using lower bit-rate electronic components. This well-known solution has a potential to enable very high bit-rate at low costs. However, some problems are still not satisfactory solved, namely that extinction ratio between pulses (requiring best quality pulse sources) are sufficient to minimize possible interferometric noise and that temporal interleave between tributaries are good enough.

Summary of the invention:

It is an object of the present invention to improve the OTDM technique allowing to increase substantially the bit–rate of data stream without suffering from restrictions due to side effects.

This object is attained by an optical module containing an optical multiplexer with at least an optical data access, an optical probe access and an optical data output. An optical data signal carried by n different interleaved wavelength channels each at a bit–rate F/n as well as an optical clock signal at frequency F and at wavelength λ_c are launched respectively on said at least one optical data access and said optical probe access such that in said optical multiplexer said optical data signal is synchronized with said optical clock signal to give a converted optical time domain multiplexed signal on said optical data output at a bit–rate F and at wavelength λ_c.

Furthermore, its object is also achieved by a method for synchronizing an optical data signal carried by n different interleaved wavelength channels each at a bit–rate F/n using an optical clock signal at frequency F and at wavelength λ_c by launching said optical data signal and optical clock signal respectively on at least one optical data access and an optical probe access of an optical multiplexer, while in said optical multiplexer said optical data signal is converted to give an optical time domain multiplexed signal on said optical data output at a bit–rate F and at wavelength λ_c.

The present invention propose to use an optical multiplexer associated with an optical clock as a wavelength converter. Each RZ coded tributary will be carried by a single wavelength (channel) passively interleaved with the others without interferometric interaction hence achieving a not necessarily perfect OTDM. This input data stream as optical data signal composed of different wavelengths is then launched on at least one data access of said optical multiplexer used as a wavelength converter. An optical clock at the desired bit-rate is launched on the probe access of said optical multiplexer synchronously to the multi-wavelength data stream. At the output, the initial clock wavelength is converted on data signal using the gain conversion property of the optical multiplexer. In such a way, a data stream of substantially higher bit–rate is obtained while due to a very precise synchronization a lost of data is minimized.

Further advantageous features of the invention are defined in the dependent claims and will become apparent form the following description and the drawing.

Brief description of the drawings:

One embodiment of the invention will now be explained in more detail with reference to the accompanying drawing, in which:

Fig. 1 is a schematic view of an optical time domain multiplex principle according to the present invention;

Fig. 2 is a schematic view of a realization of an optical time domain multiplex according to fig. 1.

On figure 1 is shown a schematic view of an optical time domain multiplex principle according to the present invention using an optical module containing an optical multiplexer 1 acting as wavelength converter. Such optical multiplexer 1 shows at least one optical data access 2a, 2b (here two but could be even more) and an optical probe access 3. An optical data signal 5 made of a multi–wavelength data stream carried by n different previously interleaved wavelength channels (in this example n=4) is launched on said at least one optical data access 2a,2b. These wavelength channels may well be chosen out of the ITU grid and be possibly close–by if not contiguous. As suggested, they may well be launched in a parallel way at more then one optical data access. Each of these channels shows a bit–rate of F/n while F is the frequency of an optical clock signal 6 and at wavelength λ_c which is launched on said optical probe access 3. Latter is performed such that it is synchronous to said optical data signal 5.

In said optical multiplexer 1, the initial optical clock signal 6 is converted to give a time domain multiplexed signal 7 on said optical data output 4 at a bit–rate F and at same wavelength λ_c. As an optical multiplexer 1 can be used a semiconductor optical amplifier Mach–Zehnder type interferometer 9 (SOA–Mzi). Alternately can be also used a non–linear optical loop mirror. It is take advantage of the gain conversion property of said optical multiplexer 1.

If for instance 4 channels at 10Gbit/s passively interleaved are launched on the optical data access as a multi–wavelength data stream, they will be converted into a single 40Gbit/s data stream inside said optical multiplexer 1. The new carrier wavelength is that of the optical clock signal λ_c (probe access). A filter is placed after said optical data output 4 of the optical multiplexer 1 to eliminate any rest contribution of the initial multi–wavelength data stream. This filter is namely centered around λ_c, let passing only the converted optical time domain multiplexed signal 7.

On figure 2 is shown a schematic realization of a time domain multiplex according to the present invention. A several channels based emitter 10 is used to synthesize data signals carried by in this example four (n=4) different wavelength channels 14a–14d at bit–rate F/n (here e.g. 10Gbit/s). The same emitter 10 is used to synthesize a clock signal at same frequency F/n. This clock signal is launched into a multipler 13 (here quadrupler) which will run an integrated electro–absorption modulator like a $LiNbO_3$ intensity modulator Mach–Zehnder in combination with a laser 12 like a DFB–one (distributed feedback laser) giving an optical clock signal at frequency F. Alternately, the quadrupler could be replaced by a simple frequency doubler if the bias operating point of the $LiNbO_3$ Mach–Zehnder is chosen at the minimum of its transfer function. This allows also to obtain an optical clock with high extinction ratio at the wished frequency F and wavelength λ_c.

The optical multiplexer 1 comprises a passive interleaver 15 which permits to interleave the different optical wavelength channels into a single multi–wavelength data stream. Latter is then launched into one or more optical data access 2a, 2b of a SOA-Mzi 9. Parallel to that and in a synchronous way is launched said optical clock signal into an optical probe access 3 of said interferometer 9. The multi–wavelength data stream and the optical clock signal will be converted in the interferometer 9 to give an optical time domain multiplexed signal on the optical data output 7 of said interferometer 9 at wavelength λ_c and bit–rate F (in the present example 40 Gbit/s).

It is possible with an optical multiplexer 1 according to the present invention to perform a method for synchronizing an optical data signal 5 carried by n different interleaved wavelength channels each at bit–rate F/n. An optical clock signal 6 at frequency F and wavelength λ_c is used while both said optical data signal 5 and optical clock signal 6 are launched respectively on at least one optical data access 2a, 2b and optical probe access 3 of said optical multiplexer 1. The synchronization is performed inside the optical multiplexer 1 to give a converted optical time domain multiplexed

signal 7 on said optical data output 4 at a bit–rate F and at wavelength λ_c. It may be of advantage afterwards, to filter out on said optical data output 4 all other optical signals except the ones at wavelength λ_c by the use of a filter 8.

The use of such an optical multiplexer 1 allows to increase substantially the bit–rate of an optical data stream without being disadvantaged by some interferometric noise. It allows to benefit of single polarization and to keep in a rigorous way the data stream equally spaced through the applied re-synchronization.